Risk Management: Assignment 5

Financial Engineering

Extended Vasicek model Monte Carlo simulation for CCR estimation

Instructions

- **Delivery:** Friday 18:00 p.m. the 9th of May to financial.engineering.polimi@gmail.com, with subject "RM: Assignment 5, Group #";
- Deliver
  a. a **short** pdf document with the results. List the errors you've found.
  b. the code written in Python using your preferred IDE;
- Fill the gaps where appropriate and correct the errors (in case of incoherences between this document and the code, follow this document);
- Comment (in detail) the code and use explicative variable names.
- Use the data and the curve bootstrapped during the Risk Management: Assignment 0.

Case Study

It is January 31st 2023 and the IR-derivative desk of Polimi Bank has just entered a position in a vanilla 8y payer IRS. The floating rate is the 3-month Euribor (Q/Q, ACT/360 day count convention with a modified-following adjustment rule); the fixed rate has a quarterly 30/360-European day count convention mod-foll. The risk management department, to evaluate the counterparty credit risk, decides to build a Monte Carlo with 250'000 simulations of the interest rate dynamics according to the Hull-White extended Vasicek interest rate model (see the code for the parameters).

Questions

1. Prove that for every simulation date s you can compute the discount factor curve as (see the Risk Management Notes for the notation):

$$B(s,\tau) = A(s,\tau)e^{-x_s C(s,\tau)}, \text{ where}$$
$$A(s,\tau) = \frac{B(t_0,\tau)}{B(t_0,s)} e^{-\frac{1}{2}\int_{t_0}^{s}(\sigma(u,\tau)^2 - \sigma(u,s)^2)du} \text{ and}$$
$$C(s,\tau) = \frac{1-e^{a(\tau-s)}}{a}$$

2. Derive numerically the expected exposure (EE) profile (32 points in the future);
3. Derive numerically the 95% potential future exposure (PFE) profile (32 points in the future);
4. From the EE profile, derive numerically the expected positive exposure (EPE); results of your simulation allow to derive empirically the ratio between the EPE and the notional of the IRS, which can be used as a parameter for approximating the EPE without running a MC simulation. Discuss whether you can approximate the EPE using the same parameter for a receiver IRS.
5. From the PFE profile, derive numerically the Peak-PFE;
6. Repeat the analysis assuming that the counterparties agree to post collateral annually, such that the counterparty risk is fully eliminated at each collateral posting date. How does this assumption affect the results?
   Hint: The CRR metrics should be computed on the total exposure: the swap MTM minus the collateral value (with the proper sign). Assume that the collateral is remunerated with the risk-free rate.